PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:
H. JIM FULFORD

Serial No.: 09/624,656

Filed: July 25, 2000

For: METHOD OF CONTROLLING SHEET RESISTANCE OF METAL SALICIDE REGIONS BY CONTROLLING THE SALICIDE STRIP TIME

Examiner: K. Chen

Group Art Unit: 1765

Att'y Docket: 2000.043500/TT3203

APPEAL BRIEF

CERTIFICATE OF FACSIMILE
37 C.F.R. 1.6(d)

I hereby certify that this correspondence is being facsimile transmitted to the Examiner K.Chen, c/o U.S.P.T.O. Assistant Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450, facsimile number 1-703-872-9311 on the date below:

08/25/03
Date

Kathy Nauas
Signature

BOX AF
Commissioner of Patents
Arlington, VA

Sir:

Applicant hereby submits this Appeal Brief to the Board of Patent Appeals and Interferences in response to the final Office Action dated May 2, 2003 and pursuant to the Notice of Appeal filed June 25, 2003.

The Assistant Commissioner is authorized to deduct the fee for filing this Appeal Brief ($320) from **Advanced Micro Devices, Inc.'s Deposit Account 01-0365/TT3203**. In the event the monies in that account are insufficient, the Assistant Commissioner is authorized to withdraw funds from Williams, Morgan & Amerson's P.C. Deposit Account 50-0786/2000.043500.

I. REAL PARTY IN INTEREST

The present application is owned by Advanced Micro Devices, Inc. The assignment of the present application to Advanced Micro Devices, Inc., is recorded at Reel 011127, Frame 0575.

II. RELATED APPEALS AND INTERFERENCES

Applicant is not aware of any related appeals and/or interferences that might affect the outcome of this proceeding.

III. STATUS OF THE CLAIMS

Claims 1-19 and 28-31 are pending in the application. The claims as currently pending are attached as Appendix A. Claims 1-19 and 28-31 stand rejected under 35 U.S.C. § 103(a) as being obvious over admitted prior art and *Choi*, et al (U.S. Patent No. 4,663,191), *Holloway*, et al (U.S. Patent No. 4,657,628), *Maris*, et al (U.S. Patent No. 5,844,684), and *Mifune*, et al (U.S. Patent No. 5,298,278).

IV. STATUS OF AMENDMENTS

There were no amendments after the final rejections.

V. SUMMARY OF THE INVENTION

Field effect transistors typically include a gate dielectric, a gate electrode, a plurality of sidewall spacers, and multiple source/drain regions. To reduce the contact resistance of the source/drain regions and the gate electrode, metal silicide regions may be formed on the source/drain regions and on the gate electrode by, *e.g.*, annealing a layer of refractory metal. However, portions of the refractory layer may not react to form metal silicide. For example, in areas where the refractory metal layer is not in contact with polysilicon, *e.g.*, the surface of the sidewall spacers, the refractory metal layer will not be converted to a metal silicide. However, it is imperative that no "bridging" material, such as un-reacted portions of the refractory layer, be left between the metal silicide regions formed above the source/drain regions and the gate electrode. Otherwise, a short circuit path may be established that may severely hamper or prevent the functioning of this device.

The un-reacted refractory metal layer is therefore typically removed using a dilute acid bath, such as a bath comprised of sulfuric acid and hydrogen peroxide. In an effort to insure that essentially all of the un-reacted refractory metal is removed from places where it should not be, the removal process is designed for a "worst-case" situation. That is, the parameters of the removal process used to remove the un-reacted refractory metal are set based upon the greatest thickness anticipated for the refractory metal, *i.e.*, existing methods set the duration of the chemical removal process based upon the thickest layer of refractory metal that may be anticipated by the process. However, in situations where the layer of refractory metal is less than the maximum thickness anticipated by the design process, designing for a "worst-case" situation results in subjecting the device to the etching process for longer than would otherwise be

required to remove the un-reacted portions of the layer of refractory metal. This over-etching needlessly consumes some of the thickness of the metal silicide regions, which undesirably increases the sheet resistance of the metal silicide regions.

Thus, with regard to independent claim 1, Applicant describes and claims forming a layer comprised of a refractory metal, determining a thickness of the layer of refractory metal, and converting a portion of the layer of refractory metal to a metal silicide. For example, a metrology tool may be used to measure the as-formed thickness of the refractory metal layer. See Patent Application, page 10, ll. 12-15. Applicant further describes and claims determining a duration of an etching process to remove un-reacted portions of the refractory metal layer based upon the determined thickness of the refractory metal layer and performing the etching process for the determined duration to remove the un-reacted portions of the refractory metal layer. With regard to independent claim 12, Applicant additionally describes and claims depositing the layer comprised of the refractory metal above a plurality of source/drain regions and a gate electrode of a transistor, as well as converting the portion of the layer of refractory metal to the metal silicide by performing at least one anneal process.

VI. ISSUE ON APPEAL

Appellant respectfully requests that the Board review and overturn the single rejection present in this case. The following issue is presented on appeal in this case: Whether claims 1-19 and 28-31 are obvious over admitted prior art and *Choi*, *Holloway*, *Maris*, and *Mifune*.

VII. GROUPING OF THE CLAIMS

For the issues presented above, claims 1-19 and 28-31 may be considered to stand or fall together.

VIII. ARGUMENT

A. Legal Standards

To establish a *prima facie* case of obviousness, three basic criteria must be met. First, there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine reference teachings. Second, there must be a reasonable expectation of success. Finally, the prior art reference (or references when combined) must teach or suggest all the claim limitations. The teaching or suggestion to make the claimed combination and the reasonable expectation of success must both be found in the prior art, and not based on applicant's disclosure. *In re Vaeck*, 947 F.2d 488, 20 U.S.P.Q.2d 1438 (Fed. Cir. 1991); M.P.E.P. § 2142. Moreover, all the claim limitations must be taught or suggested by the prior art. *In re Royka*, 490 F.2d 981, 180 U.S.P.Q. 580 (CCPA 1974). If an independent claim is nonobvious under 35 U.S.C. § 103, then any claim depending therefrom is nonobvious. *In re Fine*, 837 F.2d 1071, 5 U.S.P.Q.2d 1596 (Fed. Cir. 1988); M.P.E.P. § 2143.03.

With respect to alleged obviousness, there must be something in the prior art as a whole to suggest the desirability, and thus the obviousness, of making the combination. *Panduit Corp. v. Dennison Mfg. Co.*, 810 F.2d 1561 (Fed. Cir. 1986). In fact, the absence of a suggestion to combine is dispositive in an obviousness determination. *Gambro Lundia AB v. Baxter Health-care Corp.*, 110 F.3d 1573 (Fed. Cir. 1997). The mere fact that the prior art can be combined or

modified does not make the resultant combination obvious unless the prior art also suggests the desirability of the combination. *In re Mills*, 916 F.2d 680, 16 U.S.P.Q.2d 1430 (Fed. Cir. 1990); M.P.E.P. § 2143.01. The consistent criterion for determining obviousness is whether the prior art would have suggested to one of ordinary skill in the art that the process should be carried out and would have a reasonable likelihood of success, viewed in the light of the prior art. Both the suggestion and the expectation of success must be founded in the prior art, not in the Applicant's disclosure. *In re Vaeck*, 947 F.2d 488, 20 U.S.P.Q.2d 1438 (Fed. Cir. 1991; *In re O'Farrell*, 853 F.2d 894 (Fed. Cir. 1988); M.P.E.P. § 2142.

B. Claims 1-19 and 28-31 are not obvious over the admitted prior art and *Choi*, *Holloway*, *Maris*, and *Mifune*.

In this case, it is respectfully submitted that the obviousness rejection is improper for many reasons. First, even if the admitted prior art and the Choi, Holloway, Maris, and Mifune references are combined, they do not disclose each and every feature of the claimed invention. Second, even considering all the art and statements, there is no suggestion in the prior art of record for the entirety of the claimed invention.

As discussed above, the present invention includes, among other things, determining a thickness of the layer of refractory metal, converting a portion of the layer of refractory metal to a metal silicide, determining a duration of an etching process to remove un-reacted portions of the refractory metal layer based upon the determined thickness of the refractory metal layer, and performing the etching process for the determined duration to remove the un-reacted portions of the refractory metal layer.

The admitted prior art describes forming metal silicide regions on a gate electrode and source/drain regions by depositing a layer of refractory material above the gate electrode and the source/drain regions. Un-reacted portions of the refractory material are removed, typically using a dilute acid bath. See Patent Application, pg. 3, ll.8-25. In contrast to the present invention, the duration of the described chemical removal process is based upon the greatest thickness that may be anticipated by the process. See Patent Application, pg. 4, ll. 7-10.

Applicant respectfully submits that the methodologies set forth in the pending claims are fundamentally different from the prior art methodologies described in the background section of the application. For example, in situations where the layer of refractory metal is less than the maximum thickness anticipated by the design process, the methodologies set forth in the background section of the application, *i.e.* the admitted prior art, results in subjecting the device to the etching process for a duration longer than would otherwise be required to remove the un-reacted portions of the layer of refractory metal. In turn, this over-etching needlessly consumes some of the thickness of the metal silicide regions, which undesirably increases the sheet resistance of the metal silicide regions. For at least the aforementioned reasons, Applicants respectfully submit that the admitted prior art fails to describe or suggest determining a thickness of the layer of refractory metal. Moreover, the admitted prior art also fails to describe or suggest determining a duration of an etching process to remove un-reacted portions of the refractory metal layer **based upon** the determined thickness of the refractory metal layer and performing the etching process for the determined duration to remove the un-reacted portions of the refractory metal layer.

In the Advisory Action, the Examiner argues that the admitted prior art, and Choi, Holloway, Maris, and Mifune teach that the thickness of the refractory metal layer is determined either by design rule, by previous routine experimentation, or even by assumption. Applicant respectfully disagrees and submits that the design rules, previous routine experimentation, or assumptions invoked by the Examiner merely establish an anticipated thickness of the refractory metal layer. However, the thickness of the refractory metal layer formed by the methods set forth in independent claims 1 and 12 may differ from the anticipated thickness of the refractory metal layer described in the admitted prior art. In particular, the thickness of the formed refractory metal layer may be less than the maximum thickness anticipated by the design process. See Patent Application, page 4, ll. 11-12.

Furthermore, at least one of the cited references teaches that the thickness of the refractory metal layer formed by the methods set forth in independent claims 1 and 12 may differ from the anticipated thickness of the refractory metal. For example, Holloway teaches that the anticipated thickness of the refractory metal layer may be different than the thickness of the formed refractory metal layer. In particular, Holloway states that a thickness of a $TiSi_2$ layer formed by a silicidation reaction will be "roughly" one to two times a thickness (d1) of a titanium layer, "depending on reaction conditions." See Holloway, col. 7, ll. 50-57 and Figure 9A.

Moreover, the admitted prior art and the cited references provide no suggestion or motivation to modify the prior art to arrive at the claimed invention. In particular, the cited

references are not concerned with removing refractory material and are therefore completely silent with regard to determining a duration of an etching process to remove un-reacted portions of the refractory metal layer **based upon** the determined thickness of the refractory metal layer and performing the etching process for the determined duration to remove the un-reacted portions of the refractory metal layer. It is also believed that the admitted prior art teaches away from Applicant's claimed invention. In particular, the duration of the etching processes for removing the un-reacted refractory metal layer described in the admitted prior art were determined based upon either an assumption as to the thickness of the resulting metal silicide layer and/or the amount of un-reacted material to be removed, or established for a worst-case scenario, wherein the duration was established for the largest amount of material to be removed that could reasonably be anticipated in an effort to ensure that the essentially all of the un-reacted refractory metal is removed from places where it should not be. See Patent Application, page 4, ll. 5-11.

For at least the aforementioned reasons, Applicant respectfully submits that the obviousness rejection is improper because even if the admitted prior art and the Choi, Holloway, Maris, and Mifune references are combined, they do not disclose each and every feature of the claimed inventions. Moreover, there is no suggestion in the prior art of record for the entirety of the claimed invention.

IX. CONCLUSION

In view of the foregoing, it is respectfully submitted that the Examiner erred in not allowing all claims pending in the present application, claims 1-19 and 28-31, over the prior art

of record. The undersigned may be contacted at (713) 934-4052 with respect to any questions, comments or suggestions relating to this appeal.

Respectfully submitted,

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AGENT FOR APPLICANT

APPENDIX A

1. A method comprising:

forming a layer comprised of a refractory metal;

determining a thickness of said layer of refractory metal;

converting a portion of said layer of refractory metal to a metal silicide;

determining a duration of an etching process to remove unreacted portions of said refractory metal layer based upon said determined thickness of said refractory metal layer; and

performing said etching process for said determined duration to remove said unreacted portions of said refractory metal layer.

2. The method of claim 1, wherein forming a layer comprised of a refractory metal comprises depositing a layer comprised of a refractory metal.

3. The method of claim 1, wherein forming a layer comprised of a refractory metal comprises forming a layer comprised of a refractory metal comprised of at least one of cobalt, titanium, tantalum and nickel.

4. The method of claim 1, wherein forming a layer comprised of a refractory metal comprises forming a layer comprised of a refractory metal above a plurality of source/drain regions and a gate electrode of a transistor.

5. The method of claim 1, wherein determining a thickness of said layer of refractory metal comprises determining a thickness of said layer of refractory metal based upon a single measurement of said layer of refractory metal.

6. The method of claim 1, wherein determining a thickness of said layer of refractory metal comprises determining a thickness of said layer of refractory metal based upon multiple measurements of said layer of refractory metal.

7. The method of claim 1, wherein determining a thickness of said layer of refractory metal comprises determining an average thickness of said layer of refractory metal.

8. The method of claim 1, wherein converting a portion of said layer of refractory metal to a metal silicide comprises performing at least one anneal process to convert a portion of said layer of refractory metal to a metal silicide.

9. The method of claim 1, wherein converting a portion of said layer of refractory metal to a metal silicide comprises performing at least two anneal processes to convert a portion of said layer of refractory metal to a metal silicide.

10. The method of claim 1, wherein determining a duration of an etching process to remove unreacted portions of said refractory metal layer based upon said determined thickness of said refractory metal layer comprises calculating a duration of an etching process to remove

unreacted portions of said refractory metal layer based upon said determined thickness of said refractory metal layer.

11. The method of claim 1, wherein determining a duration of an etching process to remove unreacted portions of said refractory metal layer based upon said determined thickness of said refractory metal layer comprises selecting a duration of an etching process to remove unreacted portions of said refractory metal layer from a database that correlates the duration of the etching process to said determined thickness of said refractory metal layer.

12. A method comprising:

depositing a layer comprised of a refractory metal above a plurality of source/drain regions and a gate electrode of a transistor;

determining a thickness of said layer of refractory metal;

converting a portion of said layer of refractory metal to a metal silicide by performing at least one anneal process;

determining a duration of an etching process to remove unreacted portions of said refractory metal layer based upon said determined thickness of said refractory metal layer; and

performing said etching process for said determined duration to remove said unreacted portions of said refractory metal layer.

13. The method of claim 12, wherein depositing a layer comprised of a refractory metal comprises depositing a layer comprised of a refractory metal comprised of at least one of cobalt, titanium, tantalum and nickel.

14. The method of claim 12, wherein determining a thickness of said layer of refractory metal comprises determining a thickness of said layer of refractory metal based upon a single measurement of said layer of refractory metal.

15. The method of claim 12, wherein determining a thickness of said layer of refractory metal comprises determining a thickness of said layer of refractory metal based upon multiple measurements of said layer of refractory metal.

16. The method of claim 12, wherein determining a thickness of said layer of refractory metal comprises determining an average thickness of said layer of refractory metal.

17. The method of claim 12, wherein converting a portion of said layer of refractory metal to a metal silicide by performing at least one anneal process comprises converting a portion of said layer of refractory metal to a metal silicide by performing at least two anneal processes.

18. The method of claim 12, wherein determining a duration of an etching process to remove unreacted portions of said refractory metal layer based upon said determined thickness of said refractory metal layer comprises calculating a duration of an etching process to remove

unreacted portions of said refractory metal layer based upon said determined thickness of said refractory metal layer.

19. The method of claim 12, wherein determining a duration of an etching process to remove unreacted portions of said refractory metal layer based upon said determined thickness of said refractory metal layer comprises selecting a duration of an etching process to remove unreacted portions of said refractory metal layer from a database that correlates the duration of the etching process to said determined thickness of said refractory metal layer.

28. The method of claim 25, wherein determining the thickness of said layer of refractory metal based upon the single measurement of said layer of refractory metal comprises determining the thickness of said layer of refractory metal based upon the single measurement of said layer of refractory metal performed by a metrology tool.

29. The method of claim 26, wherein determining the thickness of said layer of refractory metal based upon multiple measurements of said layer of refractory metal comprises determining the thickness of said layer of refractory metal based upon multiple measurements of said layer of refractory metal performed by a metrology tool.

30. The method of claim 14, wherein determining the thickness of said layer of refractory metal based upon the single measurement of said layer of refractory metal comprises determining the thickness of said layer of refractory metal based upon the single measurement of said layer of refractory metal performed by a metrology tool.

31. The method of claim 15, wherein determining the thickness of said layer of refractory metal based upon multiple measurements of said layer of refractory metal comprises determining the thickness of said layer of refractory metal based upon multiple measurements of said layer of refractory metal performed by a metrology tool.